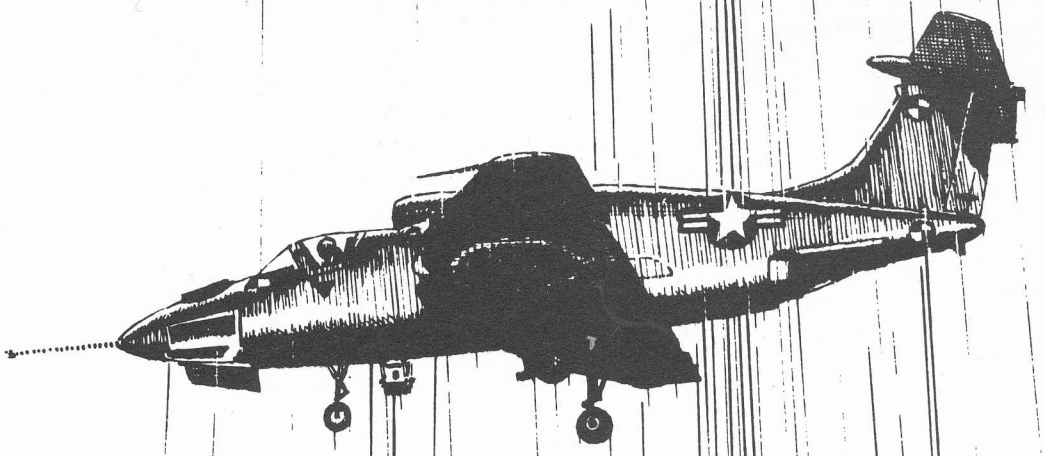


S.E.R.
XV-5A
FLIGHT
TEST SUMMARY

XV-5A FLIGHT TEST PROGRAM

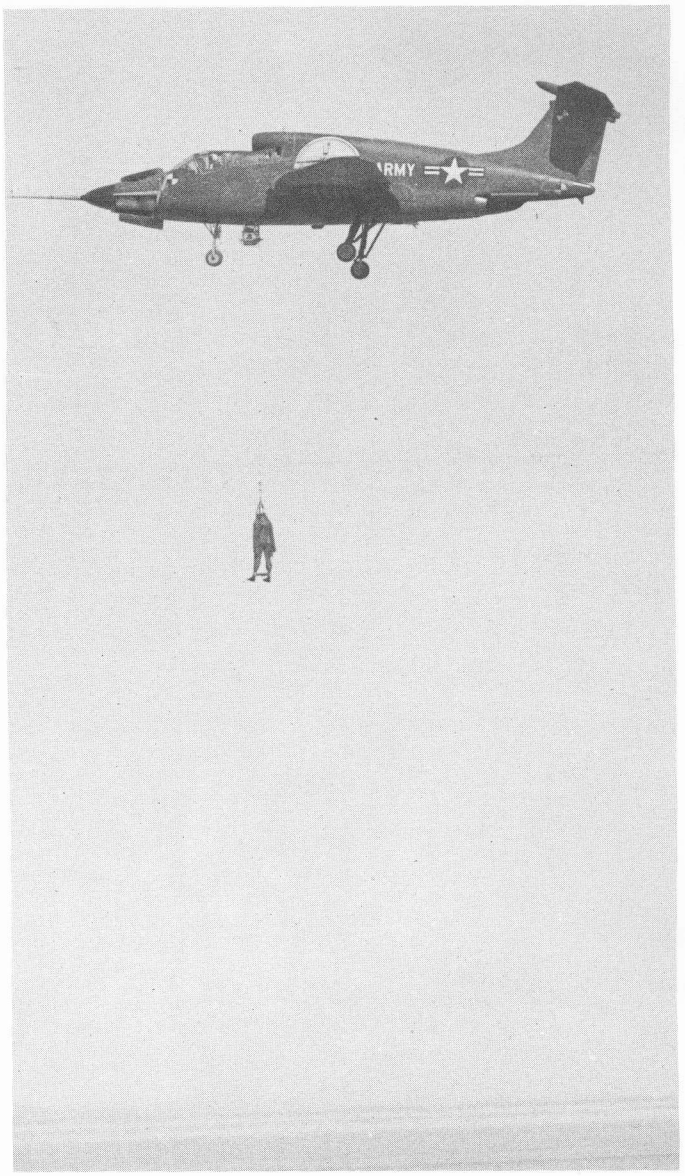
U. S. ARMY
RYAN AERONAUTICAL CO.
GENERAL ELECTRIC CO.

Contract Date	Nov. 15, 1961
Rollout	Feb. 26, 1964
First Flight	May 26, 1964
First Hover	July 16, 1964
First Complete Transition	Nov. 6, 1964
Army Acceptance	Jan. 26, 1965
Phase I Contractor Flight Test	Feb. 1964-Jan. 1965
Phase IA Contractor Flight Test	Jan. 1965
Phase II Army Flight Test	Feb. 1965-Nov. 1965
Extended Army Test (Soil-Erosion—Pilot Check Out)	Nov. 1965-Jan. 1966
Modification Lay Up	Jan. 1966-Aug. 1966
Modification Flight Test	Aug. 1966-Sept. 1966
SER (Strike Escort Rescue) Evaluation	Oct. 1966
Total Flights	368
Total Flight Hours	138
Pilots Qualified	15

INTRODUCTION

This briefing outlines and illustrates the progress made during the past 12 months in the flight test and mission development of the lift-fan concept. System utility, potential, the strike escort rescue requirement and flight test results will be reviewed.

Since the end of Army Phase II testing on November 12, 1965, the XV-5A has made 101 test flights and has undergone a 6 month lay-up for modification and major overhaul. Nine additional pilots were checked out in the aircraft and three separate test programs were carried out. All significantly added to the establishment of the Strike Escort Rescue (S.E.R.) mission capability. The present XV-5A has been damaged and will not return to flight status for some months. This briefing document reports on the current "state of the art" based on flight test results to date.



1966 XV-5A FLIGHT TEST SUMMARY

PROGRAM	FLIGHTS	HOURS JET	HOURS FAN	PURPOSE
Gov't Pilot Check Out	53	12	7½	To check out 8 gov't pilots.
Terrain Evaluation	16	2	2	To determine XV-5A operating characteristics at unprepared sites.
Modification Evaluation Mechanical Int. Pitch Fan Diversion Sequential Conversion	24	5	4	To evaluate system modifications resulting from Phase I and II testing.
S.E.R. Evaluation	8	1	1	To demonstrate and evaluate search and rescue capability of the XV-5A concept.

FLIGHT TEST RESULTS

PILOT CHECK OUT PROGRAM

This program was conducted at Edwards AFB to obtain additional government pilot evaluation of the XV-5A. The program is summarized on the accompanying chart. All the pilots were relatively experienced government test pilots and in no case did they have any difficulty flying this aircraft in either jet or fan mode. They were unanimously enthusiastic about the hovering characteristics and the ease with which the aircraft could be flown. Criticisms were generally consistent and were confined to specific areas peculiar to the XV-5A rather than inherent features of the fan system. These included such items as jet mode control harmony, trim rates and trim authority, ground handling inadequacies, human engineering factors and cockpit layout preferences. The flight training program was preceded by a short ground school and simulator program conducted at San Diego. This program brought the XV-5A qualified pilot total to 15.

PILOT CHECK OUT PROGRAM

PILOT	AGENCY	FLIGHTS	TIME TOTAL	TIME JET	TIME FAN	CONVERSIONS JET→FAN	CONVERSIONS FAN→JET	VERTICAL T/O'S
Maj. Baldwin	USAF/AFFTC	5	2:05	1:25	:40	3	2	4
Mr. Champine	NASA Langley	5	1:50	1:10	:40	4	3	3
Mr. Gerdes	NASA Ames	5	1:50	1:05	:45	3	2	7
Mr. Hanson	FAA Okla. City	4	1:30	1:00	:30	1	1	5
Maj. Larsen*	USMC/Tri-Service V/STOL	5	2:35	1:40	:45	3	2	9
Maj. Tittle*	USAF/AFFTC	6	2:10	1:30	:50	3	2	7
Mr. Simon	USAAML/Ft. Eustis	6	2:10	1:25	:45	4	3	7
Maj. West	USAAML/Ft. Eustis	5	1:55	1:10	:45	3	2	5

*Majs. Tittle and Larsen were selected to participate in the SER evaluation program and each flew one flight.

MODIFICATION PROGRAM

The following significant modifications were incorporated during the lay up:

- Mechanical interconnect between diverter valves and horizontal stabilizer.
- Pitch Fan diversion System.
- Sequential conversion.

The mechanical interconnect was introduced to improve reliabiltiy by simplifying and mechanizing the automatic tail program during conversion. The system permitted elimination of 12 electrical relays and several hydraulic sequencing servos. It also reduced the "runaway" authority of the tail in jet mode. A series of conversions at various speeds and tail settings were made and the aircraft conversion behavior was evaluated. There was no change in conversion characteristics and the modification was considered to be a basic improvement.

The pitch fan diversion system was developed to permit fan mode flight above 60 kts. without the pitch fan and is illustrated in the accompanying chart. The pilot had control of the diversion system, but an electrical lock-out did not permit diversion of the pitch fan below a louver vector angle of less than 30° (approximately 60 kts. at zero angle of attack). Performance, stability and control and short take-off tests were flown to establish airworthiness of the system and determine the extent to which the expected benefits were realized.

The results of the tests were conclusively favorable and this capability will almost certainly be included in any future development aircraft of this configuration. The tests showed the following advantages of this system:

(A.) Reduced pitch fan intake and efflux momentum drag resulting in a marked performance improvement which can be realized in terms of:

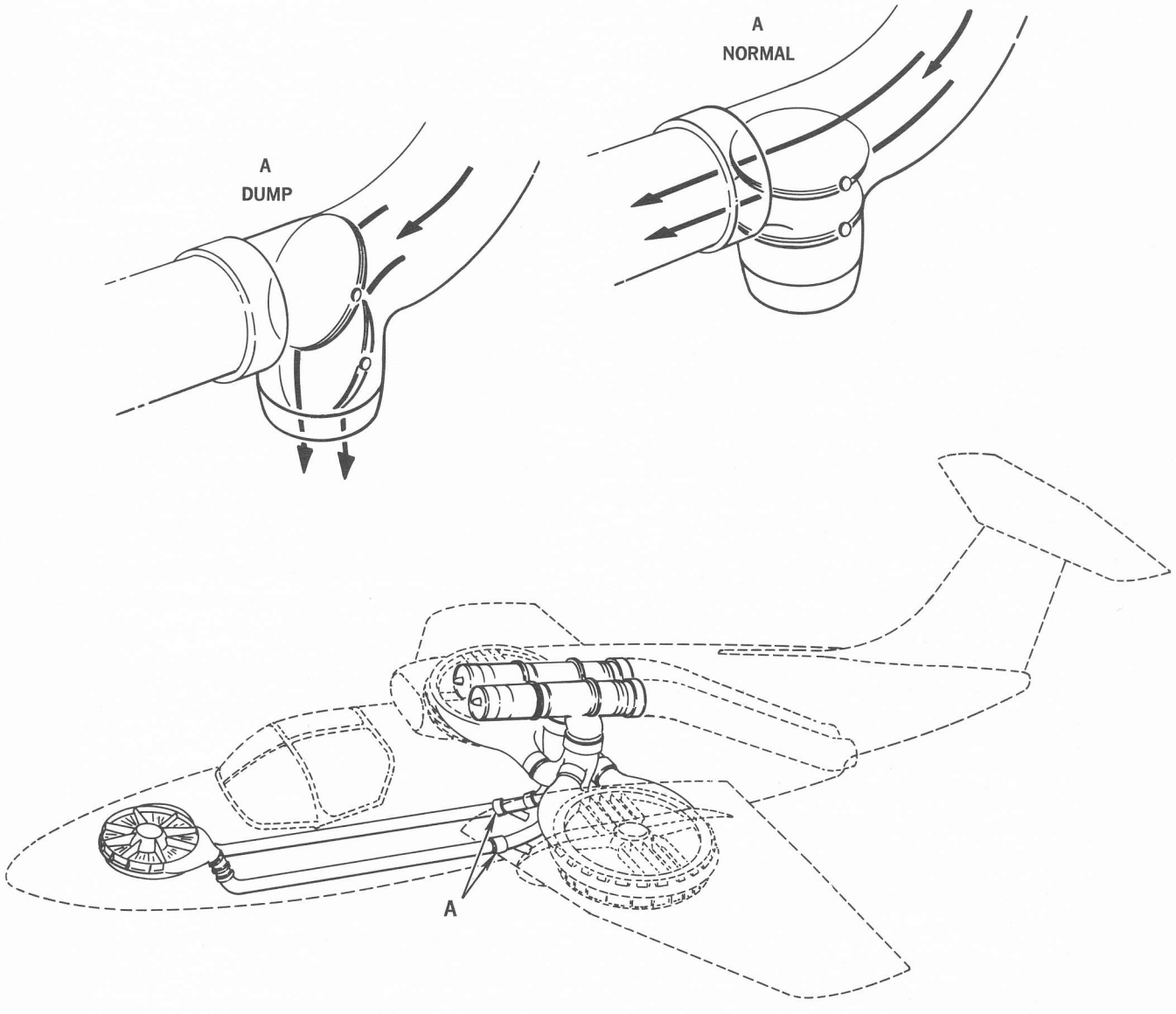
- Higher payload which can be carried to conversion speed (85 kts)
- Faster acceleration to conversion speed, i.e., reduced transition time.
- Hotter or higher ambient operating conditions.
- Increased climb performance above 60 kts.
- Increased fan mode speed (110 kts.)

(B.) Smoother more comfortable conversion due to less deceleration after conversion to fans and gentler nose down pitch rate.

(C.) Reduction in lateral response stiffness associated with high fan mode speeds due to an apparent reduction in roll rate damping created by the pitch fan. The aircraft handled in a manner more similar to that experienced in jet mode just prior to conversion, thus improving the harmony between flight regimes.

The sequential conversion modification provided a means of performing individual and sequential conversion of each engine from jet mode to fan mode in order to obtain design information for future fan systems and to determine the advantages and disadvantages of sequential conversion. The results were unimpressive and only minor performance benefits were realized. The offset thrust of the single engine caused directional trim changes during conversion and during any subsequent jet engine power change. Only one test flight was made with this system incorporated due to pressure of higher priority tests.

PITCH FAN DIVERSION SYSTEM



TERRAIN TESTS

During February 1966, the XV-5A completed a series of tests to demonstrate landing and take-off on various types of prepared and unprepared terrain to establish SER capability.

A total of eight different land sites and one water site were selected by a joint military-contractor team to provide a diversity of ground conditions for the widest possible scope of terrain testing. These test sites included:

- Sod field
- Alfalfa stubble field
- Untreated desert terrain
- T-17 nylon-neoprene mat over desert terrain.
- Asphalt stabilized desert terrain
- Gravel-hardpan area
- Barren plowed clodded field
- Loose silty sand area, approximately 14 in. deep.
- Artificial pond, approximately 415 ft. by 215 ft. to a depth of 3 feet.

Vertical landing and takeoffs were made from all the aforementioned ground surfaces with the exception of the asphalt stabilized area, the plowed field and the loose silty sand area.

Improper application of the asphalt under adverse temperature conditions did not permit adequate soil fixation and curing, and as a result, the asphalt began to break up at an aircraft height of approximately 25 feet, from impingement of fan efflux as the XV-5A descended for a landing.

Inadequate soil bearing capacity precluded landing in the plowed field and the sand areas. Under these circumstances, the XV-5A descended to heights of 15 and 20 feet respectively.

Hover descent was made over the pond area to an altitude of approximately 20 feet at which time water droplets appeared on the windshield. The ballasted life raft with sea anchor was displaced radially outward approximately 50 feet.

As a result of these tests, it is concluded that the XV-5A has the following capabilities directly related to a SER mission:

- Vertical descent and landing is practical on most surfaces of adequate bearing strength to support the aircraft without the need for soil stabilization.
- Soil stabilization methods such as the T-17 membrane would permit XV-5A take-off and landing operations on suitable level sites under marginal surface soil conditions.
- A vertical descent into a designated site from approximately 100 ft. altitude produces less disturbance than a slow pass over the site.
- The combination of vertical take-off and landing capability combined with a high subsonic speed for cruise enhances the XV-5A as a rescue aircraft compatible with the mission of ground attack aircraft.

TERRAIN TESTING SUMMARY

TERRAIN	MINIMUM ALTITUDE	LANDING POSSIBLE?	EROSION SIGNATURE	F.O.D.
Sod	0	Yes	None (Tire Prints)	None
Alfalfa Stubble	0	Yes	None (Tire Prints)	None
T-17 Membrane Mat	0	Yes	None (Tire Marks)	None
Plowed Field	15′	Yes if Adequate Bearing Capacity	Swept Area	None
Unprepared Desert Soil	0	Yes	Swept Area and 2″ Erosion	None
Asphalt Laid on Sand 4 Gals/Yd²	25′	No Asphalt Breaking Up Due to Incorrect Mixing, Low Temp. Cure	Asphalt Peeling	None
Hard Pan	0	Yes	Swept Area — Some Peeling Erosion	None
Water	20′	No	None	None
Loose Sand (14″ Deep)	20′	Yes if Adequate Bearing Capacity	Swept Area	None

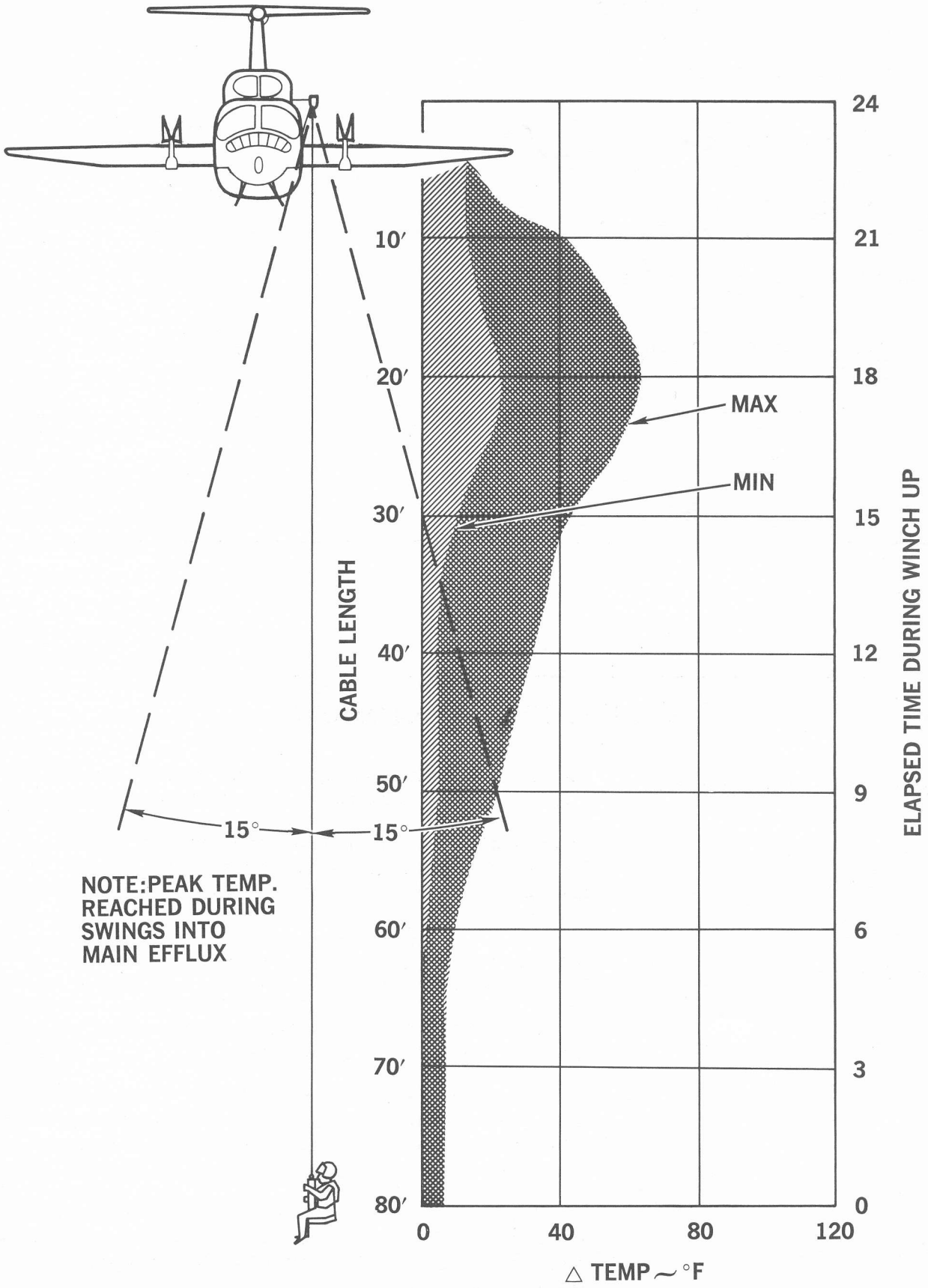
S.E.R. WINCHING TESTS

Under instructions from the Director of Defense Research and Engineering an evaluation test organization was established to demonstrate and evaluate the XV-5A in the Search and Rescue Mission. The aircraft was modified to carry a 600-lb. capacity side mounted winch, a side mounted convex mirror and two motion picture cameras. An anthropomorphic dummy was prepared with a self contained oscillograph to record temperature, motion and loads data. Testing commenced with a functional test flight of the winch and camera installation followed by hover winching tests to qualify the entire system for a live pick up demonstration. Dummy and empty hook behavior was found to be very satisfactory and a low speed winching envelope was established. The high winch rate of 200′/min. was required to expedite the rescue, but the start stop transient loads were excessive at this rate. In addition, the start-stop "jolt" tended to initiate dummy swinging and thereby increasing temperatures as the fan efflux was penetrated. Steady winching with no aircraft transient motions gave the lowest temperatures and loads. In some cases the dummy could be winched up without exceeding a head temperature rise of over 60°F. The highest recorded transient peak temperature rise was 126°F, obtained with the dummy hanging at 20 feet and swinging gently.

Some form of visual acquisition of the pick up area was found to be necessary and a 13″ convex mirror was evaluated for this reason. A fold out, adjustable mirror would provide one solution to the problem, although alternative systems are also possible, such as an optical sight, closed circuit T.V., open canopy panel, etc. Accurate cable length and aircraft height information is also required for pilot only operation.

A professional subject was chosen for the live pick up demonstration and after participating in the preliminary testing he indicated complete willingness and confidence in making the tests.

DUMMY HEAD TEMPERATURE DURING HOISTING OPERATION



SUMMARY OF MAXIMUM DUMMY VERTICAL LOADS

CONDITION	WINCH* RATE	LOAD G
Starting Winch Up From Hanging	High	1.9
	Low	1.5
Stop Winching Up from Continuous Up	High	0
	Low	.25
Start Winching Down from Hanging	High	0
	Low	0
Stop Winching Down from Continuous Down	High	2.8
	Low	1.8
Cycle Winch Switch During Continuous Up Winching (On/Off)	High	0/2.7
	Low	0/1.75
Cycle Winch Switch During Continuous Down Winching (On/Off)	High	2.8/0
	Low	1.9/0.5

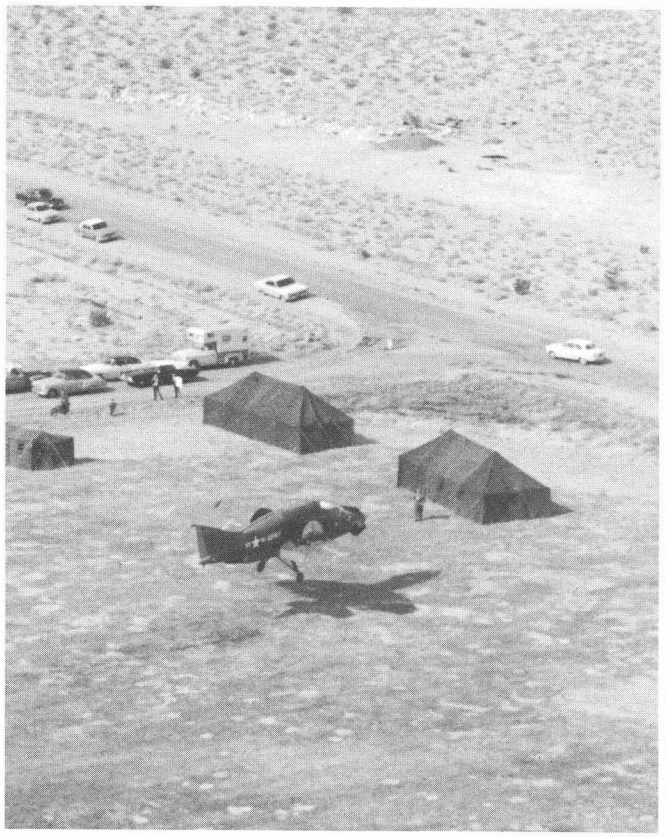
*High 200'/Min
Low 100'/Min

S.E.R. TEST CONCLUSIONS

Operations From Unprepared Sites . . .	Good characteristics. Landings and take-offs can be made on a wide variety of surfaces with adequate bearing capacity.
Winching Operations	Aircraft positioning and control during rescue very satisfactory. Dummy winching behavior was satisfactory. Stable A/C hovering platform makes winching an easy pilot task. One-man operation is possible.
Human Environment	Temperatures appear compatible with human tolerances. Ground environment satisfactory with aircraft hovering at 100'+.
"S.A.S. Off" Hovering & Vert. Ldg. . . .	Demonstrated safe SAS off hover and vertical landing. Require improved SAS failure warning.
Winch Location	Side location not optimum for pilot attention, survivor ease of entry and potential F.O.D. Centerline through the belly location recommended. This location also results in more stable dummy behavior.
Equipment	Aircraft and sling height display required. Visual presentation (mirror, optical, TV or direct) needed. Less abrupt winch stop/start characteristics to reduce transient loads. Communication between pilot and survivor on cable required.

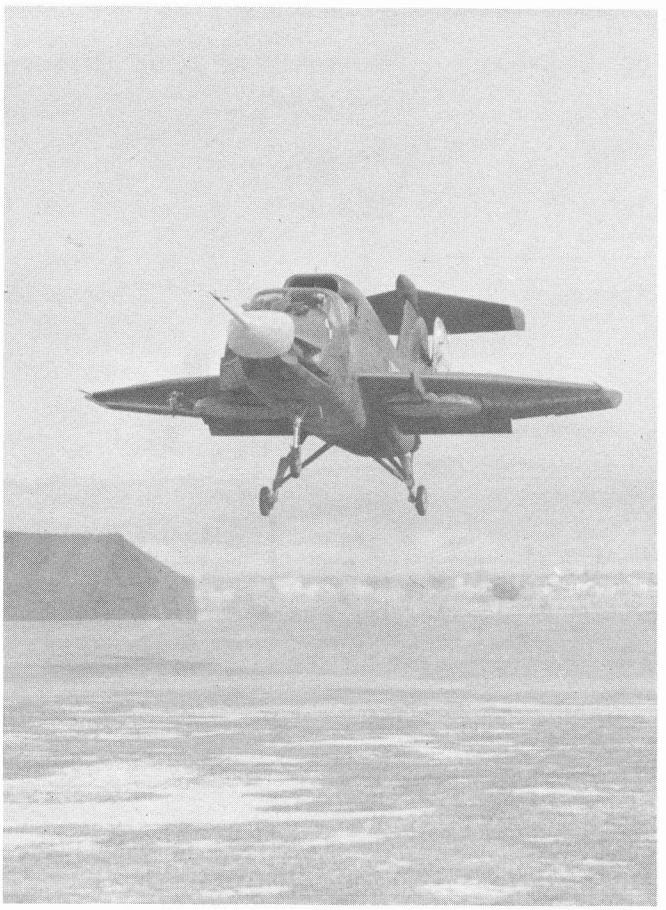
TERRAIN TEST: SOD

Site:	Golf driving range (clear area)
Location:	N.A.F. China Lake
Soil Condition:	Bermuda & blue grass (Silty sand)
Wind:	Calm
Temp:	42°F
Approach:	
Descent:	Vertical step descent from 50 ft. Ground disturbance at 30-35 ft., clippings and dirt at 2-3 ft. radially outward. Disturbance not visible below 15 ft. A/C Gen. Winds 10-15 kt. gusty 50 ft. outward.
Lift Off:	Very little disturbance
Signature:	Tire prints ½" deep
Comments:	No erosion. Little evidence of operation at site.



TERRAIN TEST: SOD

Site:	Golf driving range (encampment)
Location:	N.A.F. China Lake
Soil Condition:	Bermuda & blue grass (silty sand)
Wind:	Calm
Temp:	53°F
Approach:	Tumbleweed and dust to wing level during approach over desert at 35 ft. No impairment of vision. Dust cloud subsided over sod area.
Descent:	Steady descent, little ground disturbance.
Lift Off:	Mild tent billowing with A/C 20 yards from tents.
Signature:	No erosion. Little evidence of operation at site.
Comments:	Operation is compatible in proximity to ground equipment and personnel.



TERRAIN TEST: ALFALFA FIELD

Site:	Unprepared field
Location:	12 miles S.W. EAFB
Soil Condition:	Mowed stubble 2″ high (lean clay, very moist)
Wind:	3 knots
Temp:	33°F

Approach:	Decreasing height S-N pass at 15 kts., from 100 ft. to 15 ft. Dust bow wave developed behind A/C to height of approximately 15 ft. No visual impairment.
Descent:	Step descent resulted in sweep of area at approximately 30 ft., radially outward at 2-3 ft. Disturbance subsided near ground.
Lift Off:	Very little disturbance.
Signature:	MLG tire prints ½″ deep.
Comments:	Very slight evidence of ground erosion. Main landing gear only on ground because of low soil bearing strength.

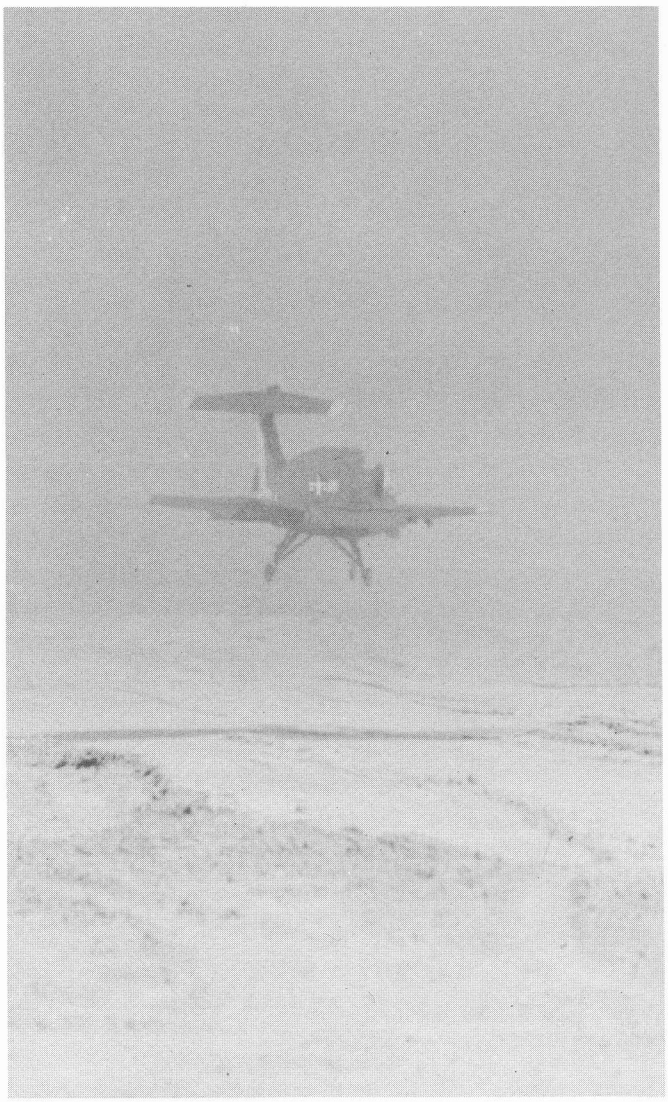
TERRAIN TEST:
T-17 NYLON NEOPRENE MAT.

Site:	NASA construction site
Location:	½ mile N.W. NASA hdqrs.
Soil Condition:	Top 12″-18″ removed. No vegetation (silty clayey sand)
Wind:	3 knots
Temp:	43°F
Approach:	Pass from south at 15 kts. from 90 ft. to 15 ft. Dust cloud 20 ft. high at 50 ft. altitude with bow wave below nose wheel, bow wave was under pitch fan at 30 ft. altitude.
Descent:	Dust cloud developed at 50 ft., 20 ft. high at 25 ft. altitude. Caking flakes of dirt at mat periphery. Cloud dissipated as A/C descended. No visibility problem.
Lift Off:	Very little disturbance.
Signature:	Tire marks on mat.
Comments:	Mat feasible for operation if adequate soil bearing strength.

TERRAIN TEST:
UNTREATED DESERT TERRAIN

Site:	NASA construction site
Location:	½ mile N.W. NASA hdqrs.
Soil Condition:	Top 12"-18" removed. No vegetation. (silty clayey sand)
Wind:	4 knots
Temp:	38°F

Approach:	
Descent:	Vertical step descent from 100 ft. with light dust. Dust cloud intensity built up at 60 ft. to a maximum at 30 ft. with chipping of crusted dirt. Large dust cloud, but A/C visible.
Lift Off:	Active chipping of dirt, chunks thrown radially outward. Less dust probably due to sweeping action during descent.
Signature:	Ground under fans eroded to depth of 2 in. to moist clay. Circle of 42 ft. radius swept free of dirt and pebbles.
Comments:	Landing and take-off accomplished satisfactorily.



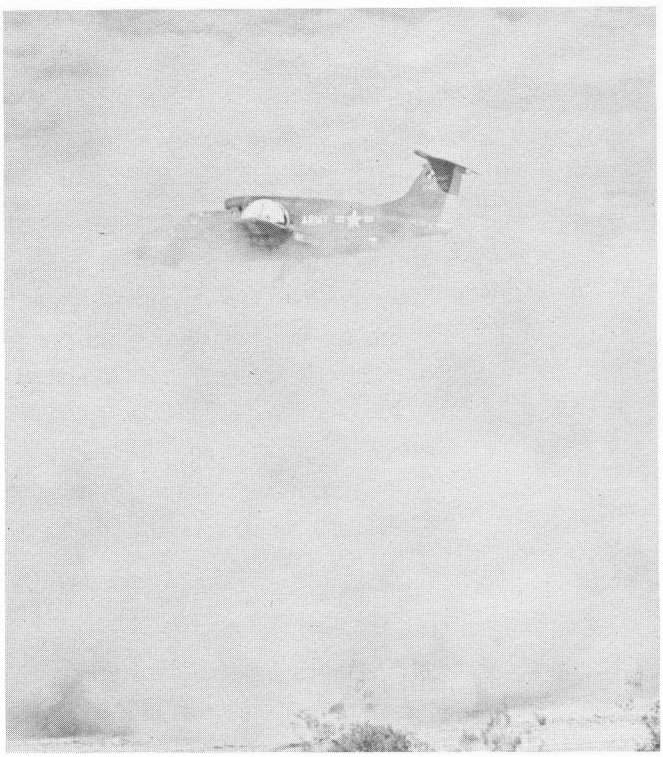
TERRAIN TEST: ASPHALT TREATED SITE

Site:	NASA construction site
Location:	½ mile N.W. NASA hdqrs.
Soil Condition:	Top 12"-18" removed. No vegetation (silty clayey sand) with cationic emulsified asphalt surface.
Wind:	4 knots
Temp:	38°F
Approach:	
Descent:	Vertical step descent caused light dust clouds to be raised at 25 ft. above the surface, asphalt began breaking up and peeling off. Large pieces were lifted approximately 1 ft. and blew radially outward about 5 ft., with smaller pieces out to 40 ft. No landing was attempted due to surface disintegration.
Climb Out:	Very little additional surface break up.
Comments:	Asphalt was improperly applied and as such was worse than unprepared surface.

TERRAIN TEST: GRAVEL HARDPAN

Site:	West overrun area off runway
Location:	South base runway EAFB
Soil Condition:	Top ½ inch—Uniform coarse to medium sand, lower surfaces-silty sand.
Wind:	Calm
Temp:	38°F

Approach:	
Descent:	Vertical descent from 100 ft. Light dust rose at 50 ft. followed by formation of a large dense dust cloud to left of A/C. Area to right and rear was clear. Gravel was swept radially outward and some dirt clods were broken away in close proximity to ground. All dust cleared just prior to touchdown.
Lift Off:	Very little dust. Some clod break up.
Signature:	Small amount of erosion and swept area.
Comments:	No problems encountered in landing or take-off.



TERRAIN TEST: PLOWED CLODDED FIELD

Site:	Barren cultivated area, normally planted.
Location:	10 miles S.W. EAFB
Soil Condition:	2″-4″ earth clods, low bearing capacity and irregular surface (sandy silty clay)
Wind:	3 knots
Temp:	33°F
Approach:	
Descent:	Vertical step descent from 100 ft. Dust clouds developed at 50 ft. height, followed by clod break up and higher density dust cloud. At 15 ft. height the A/C was obscured from observers viewing from the front, but was visible to those on the side. A dust cloud formed in front of the A/C in an arc from 11 o'clock to 5 o'clock position, but did not approach the A/C. The pilot did not lose ground visibility.
Ascent:	Uneventful
Signature:	Peaks tended to erode and fill troughs. Some clods blown outboard.
Comments:	Estimated cloud height—dense to 50 ft. light to 200 ft. No landing was contemplated due to low soil bearing strength and irregular surface. No hazard to operation close to ground.

TERRAIN TEST: LOOSE SILTY SAND

Site:	Drop zone
Location:	3-4 miles W. of G.E. EAFB
Soil Condition:	Silty sand, plowed and pulverized. Inadequate soil bearing capacity makes landing impossible. Sand 14" deep, 10% vegetation.
Wind:	7 knots
Temp:	48°F
Descent:	Vertical step descent from 100 ft., started cloud formation. Dense dust cloud to 30 ft. at 50 ft. altitude. Dust came over wing at 40 ft., but moved outboard as A/C descended. A/C was obscured from ground observers at estimated 20 feet altitude. Pilot lost visual horizon reference but maintained visual ground contact underneath.
Ascent:	Uneventful. No landing planned.
Signature:	No surface erosion, loose dust blown through sweeping action.
Comments:	Could land A/C if essential.

TERRAIN TEST: WATER

Site:	Pond 2′-4′ deep. Length = 415′, Width = 215′
Location:	E. of contractor's row taxiway EAFB.
Test Equipment:	Two life rafts with 200-lb. ballast each, one free, one anchored.
Wind:	3 knots
Temp:	41°F
Descent:	Step descent over free raft from 100 ft. Raft started moving south. Spray wisps 2′-3′ high. At 70 ft. altitude, spray was visible at wheel height. Water sheets visible at wing level at 30 ft. Water drops on windshield at 20 ft. Dishing effect at 50 ft. gave way to two separate holes at 30 ft. Same phenomenon with raft and sea anchor, except raft motion limited to 50 ft. on surface.
Climb Out:	Uneventful.
Signature:	Predictable vortex pattern from fan efflux while over water.
Comments:	Hover operation feasible at height above 20 feet.

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